PCT/AU2004/001339

AUSTRALIA

REC'D 18 OCT 2004
WIPO PCT

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Patent Office
Canberra

I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003905325 for a patent by BHP BILLITON INNOVATION PTY LTD as filed on 30 September 2003.

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

WITNESS my hand this
Thirteenth day of October 2004

J. Billingsley

JULIE BILLINGSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant(s):

BHP BILLITON INNOVATION PTY LTD

A.C.N. 008 457 154

Invention Title:

POWER GENERATION

The invention is described in the following statement:

POWER GENERATION

The present invention relates to a method and an apparatus for generating electrical power that is based on the use of coal bed methane gas as a source of energy for driving a gas turbine and a steam turbine for generating the power.

The term "coal bed methane" is understood herein to mean gas that contains at least 90% methane gas on a volume basis obtained from an underground coal source.

According to the present invention there is provided a method of generating power via a gas turbine and a steam turbine which comprises:

(a) supplying coal bed methane, an oxygen-containing gas, and flue gas produced in the gas turbine, all under pressure, to a combustor of the gas turbine and combusting the coal bed methane and using the heated combustion products and the flue gas to drive the gas turbine;

(b) supplying a hot flue gas stream produced in the gas turbine to a heat recovery steam generator and using the heat of the flue gas to generate steam by way of heat exchange with water supplied to the steam generator;

(c) suppling steam from the steam generator to a steam turbine and using the steam to drive the steam turbine; and

(d) supplying a part of the flue gas from the steam generator to the combustor of the

turbine and another part of the flue gas from the steam generator to a suitable underground storage region.

One of the features of the method and the apparatus of the present invention is that it produces no CO_2 emissions. Supplying the CO_2-containing flue gas that is not supplied to the gas turbine is an effective option for preventing CO_2 emissions into the atmosphere that does not have any adverse environmental consequences.

Another feature of the method and the apparatus of the present invention is that supplying CO_2-containing flue gas to the gas turbine is an effective option for reducing the turbine operating load.

Typically, the flue gas is predominantly CO_2.

Preferably step (d) includes supplying the flue gas to the underground storage region as a liquid phase.

Preferably the underground storage region is the coal bed seam from which coal bed methane to power the gas turbine is extracted. In this context, the existing well structures for extracting coal bed methane can be used to transfer flue gas, in liquid or gas phases, to the underground storage region.

Preferably step (d) includes separating water from the flue gas.

Step (d) may further include:

(i) compressing the flue gas to a first pressure (typically 20-30 bar);

(ii) supplying one part of the compressed flue

gas to the combustor;

(iii) compressing another part of the compressed flue gas to a second, higher pressure (typically at least 70 bar);

(iv) cooling the pressurised flue gas from step (iii) and forming a liquid phase; and

(v) supplying the liquid phase to the underground storage region and forming a gas phase.

In an alternative, although not the only other possible alternative, embodiment, step (d) may further include:

(i) compressing the flue gas (typically to at least 70 bar) and producing a high pressure flue gas stream;

(ii) cooling the pressurised flue gas and forming a liquid phase;

(iii) splitting the liquid phase into two streams and supplying one stream as a liquid phase to the underground storage region and forming a gas phase from the other stream and supplying the resultant flue gas to the combustor.

According to the present invention there is also provided an apparatus for generating power via a gas turbine and a steam turbine which comprises:

(a) a gas turbine;

(b) a means for supplying coal bed methane, an oxygen-containing gas, and flue gas produced in the gas turbine, all under pressure, to a combustor of the gas turbine for combusting the coal bed methane and using the heated combustion products and the flue gas to drive the gas turbine;

(c) a heat recovery steam generator for generating steam from water supplied to the steam generator by way of heat exchange with a flue gas from the gas turbine;

(d) a steam turbine adapted to be driven by steam generated in the steam generator;

(e) a means for supplying one part of a flue gas from the steam generator to the combustor and another part of the flue gas to a suitable underground storage region.

Preferably the means for supplying one part of a flue gas from the steam generator to the combustor and another part of the flue gas to the suitable underground storage region includes a means for converting the flue gas from a gas phase into a liquid phase to be supplied to the suitable underground storage region.

The present invention is described further with reference to the accompanying drawings, of which:

Figure 1 is one embodiment of the power generation method and the apparatus of the invention; and

Figure 2 is another embodiment of the power generation method and the apparatus of the invention.

With reference to Figure 1, the method includes supplying the following gas streams to a combustor 5 of a gas turbine generally identified by the numeral 7:

(a) coal bed methane from an underground source 3 via a dedicated coal bed methane compressor station (not shown);

(b) oxygen, in an amount required for stoichiometric combustion, produced in an air separation plant 11;

(c) flue gas, which is predominantly CO_2, that has been supplied from a flue gas stream from the turbine 7, described hereinafter.

The streams of oxygen and flue gas are pre-mixed in a mixer 9 upstream of the combustor 5.

The streams of coal bed methane and oxygen/flue gas are supplied to the combustor 5 at a preselected pressure of 22 bar.

The coal bed methane is combusted in the combustor 5 and the products of combustion and the flue gas are delivered to an expander 13 of the turbine 7 and drive the turbine blades (not shown) located in the expander 13.

The output of the turbine 7 is connected to and drives an electrical generator 15 and a multiple stage flue gas compressor train 17.

When the power generation method is operating in this mode, the air compressor 21 of the turbine 7 is disconnected from the expander 13 by way of a clutch 25.

The output gas stream, ie the flue gas, from the turbine 7 is at atmospheric pressure and typically at a temperature of the order of 540°C.

The flue gas from the turbine 7 is passed through a heat recovery steam generator 27 and is used as a heat source for producing high pressure steam, typically approximately 75 Bar or 7.5 Mpa, from demineralised water and condensate return supplied to the steam generator 27.

The high pressure steam is used to run a steam turbogenerator 29 and generate electrical power.

The flue gas from the heat recovery steam generator 27, which is predominantly CO_2 and water, and therefore leaves the steam generator as a wet flue gas stream, typically at a temperature of 125°C, via an outlet.

The wet flue gas is then passed through a water separator 33 that separates water from the stream and produces a dry flue gas stream.

The dry flue gas stream is then passed through the multiple stage flue gas compressor train 17.

In a first stage of compression the flue gas is compressed to the necessary pressure, namely 22 bar in the present instance, for the combustor 5.

Compressed flue gas from the exit of the first stage is supplied to the combustor 7 via the mixer 9, typically a mix valve, and mixes with oxygen from the air separator 11 prior to being supplied to the combustor 5.

The remainder of the flue gas is supplied to the second compression stage and is compressed to a high

pressure, typically above 73 bar and the stream of compressed flue gas is then passed through a condenser 35. The condenser 35 cools the temperature of the flue gas stream to below 31°C and thereby converts the flue gas to a liquid phase.

The liquid flue gas stream leaving the condenser is pressurised (if necessary) and then injected into existing field wells.

When the power generation system is not operating in the above-described mode and, more particularly is not receiving the stream of pre-mixed oxygen and flue gas, the clutch 25 is engaged and the turbine 7 operates on a conventional basis with air being drawn through the turbine air intake (not shown) and compressed in the air compressor 21 and thereafter delivered to the combustor 5 and mixed with coal bed methane and the mixture combusted in the combustor 5.

More particularly, the option of operating on a more conventional basis is available by disconnecting the multiple stage flue gas compressor train 17 from the turbine 7 and connecting the gas turbine air compressor 21 by engaging the clutch 21.

The embodiment of the method and the apparatus shown in Figure 2 is very similar to the embodiment shown in Figure 1 and the same reference numerals are used to indicate the same components.

The main differences between the two embodiments relate to the processing of the flue gas from the steam generator 27.

Specifically, in the embodiment shown in Figure 2 the flue gas from the steam generator 27 is passed through

a recuperator 31 and is cooled to a temperature, typically 80C, before being transferred to the water separator 33.

In addition, the dry flue gas is not split into two streams after the first stage in the multiple stage flue gas compressor train 17, as is the case in the embodiment shown in Figure 1. Rather, the whole of the dry flue gas from the water separator 33 is compressed in the compressor train 17 and then passed through the condenser 35. The liquid stream from the condenser 35 is then split into two streams, with one stream being supplied to the underground storage region and the other stream being passed through the recuperator 31 and being converted into a gas phase via heat exchange with the flue gas stream from the steam generator 27. The reformed flue gas from the recuperator 31 is then supplied to the combustor 5 via the mixer 9.

The key components of the above-described embodiments of the process and the apparatus of the invention are as follows:

(a) Air Separation Plant - This unit is required to produce oxygen for combustion of coal bed methane in the turbine combustor. Typically, the plant is a standard off-the-shelf unit sized to cope with the O_2 required for complete combustion of coal bed methane.

(b) Gas Turbine/Generator - Typically, this unit is a standard gas turbine fitted with a standard combustor. The only design change that is required to the standard gas turbine is to fit a clutch unit between the air compressor and the turbine expander. A re-design of this nature has already been carried out for machines used for compressed air storage power generation systems. The multi-stage flue gas compressor will be fitted on the same shaft with a similar clutch unit that will enable the

compressor to be isolated when the air compressor is re-engaged with the turbine expander. The attachment of large multi-stage compressors to gas turbine units is quite common in the steel industry where low Btu steelworks gases are compressed by these units before being delivered to the combustor for combustion.

(c) Heat Recovery Steam Generator - Typically, this unit is a standard double pressure unfired unit.

(d) Steam Turbine/Generator - Typically, this unit, complete with the steam cycle ancillaries, is a standard steam turbine unit.

(e) Flue Gas Recirculating and CO_2 Underground storage System - Typically, this system contains the following:

(i) Water Separator/knockout Unit - Typically this unit is a simple water separation plant in which water is knocked out of the flue gas stream prior it entering the multi-stage compressor unit.

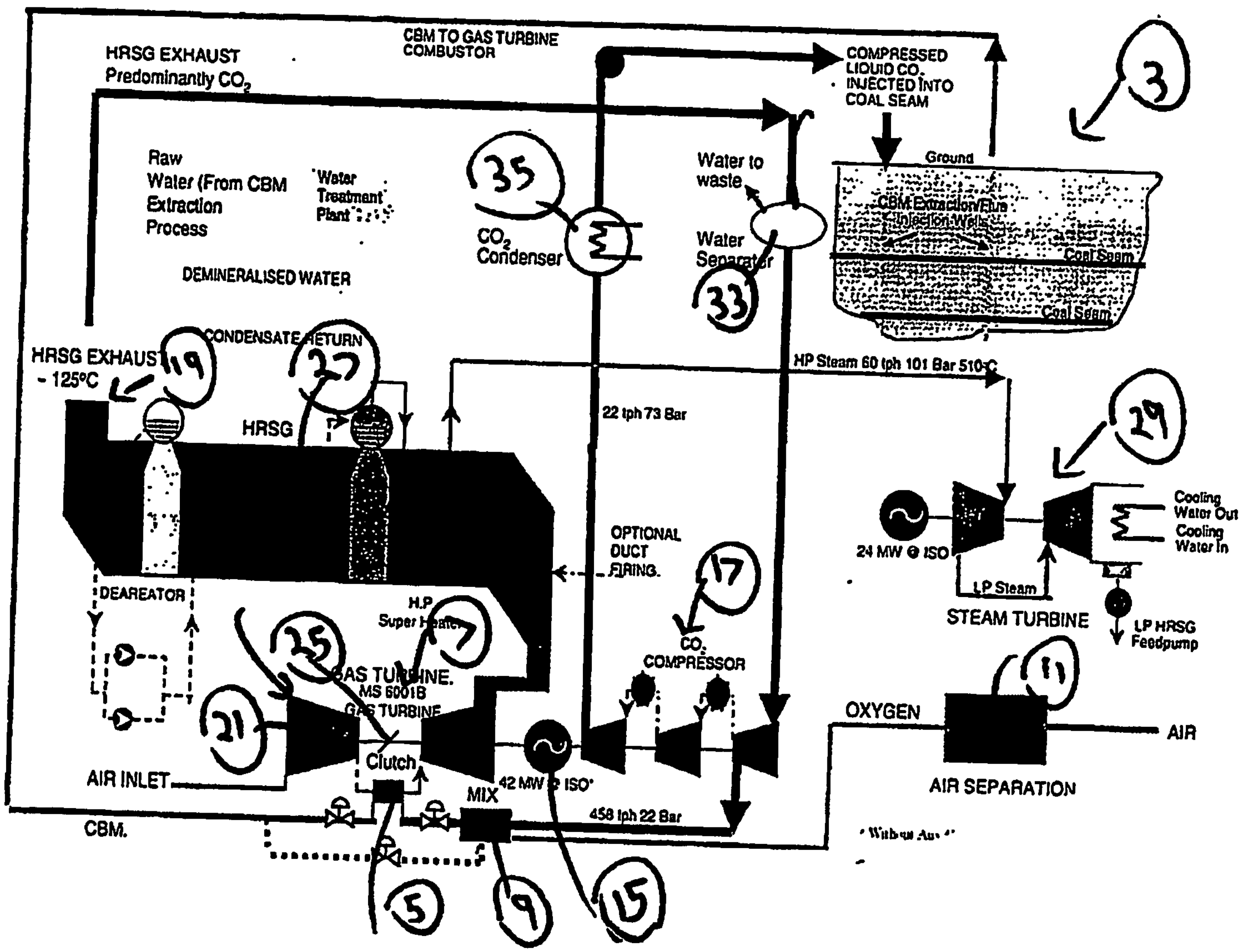
(ii) CO_2 multi-stage compressor train - For the embodiment shown in Figure 1, typically this unit is designed to handle the entire flue gas stream in the first stage of compression and the smaller stream of flue gas for underground storage. This smaller stream will be pressurised to above 70 Bar before being delivered to the condenser.

(iii) Condenser - This unit is required to produce liquid flue gas, which is predominantly CO_2, prior to injecting it to underground wells.

Many modifications may be made to the embodiments of the present invention described above without departing

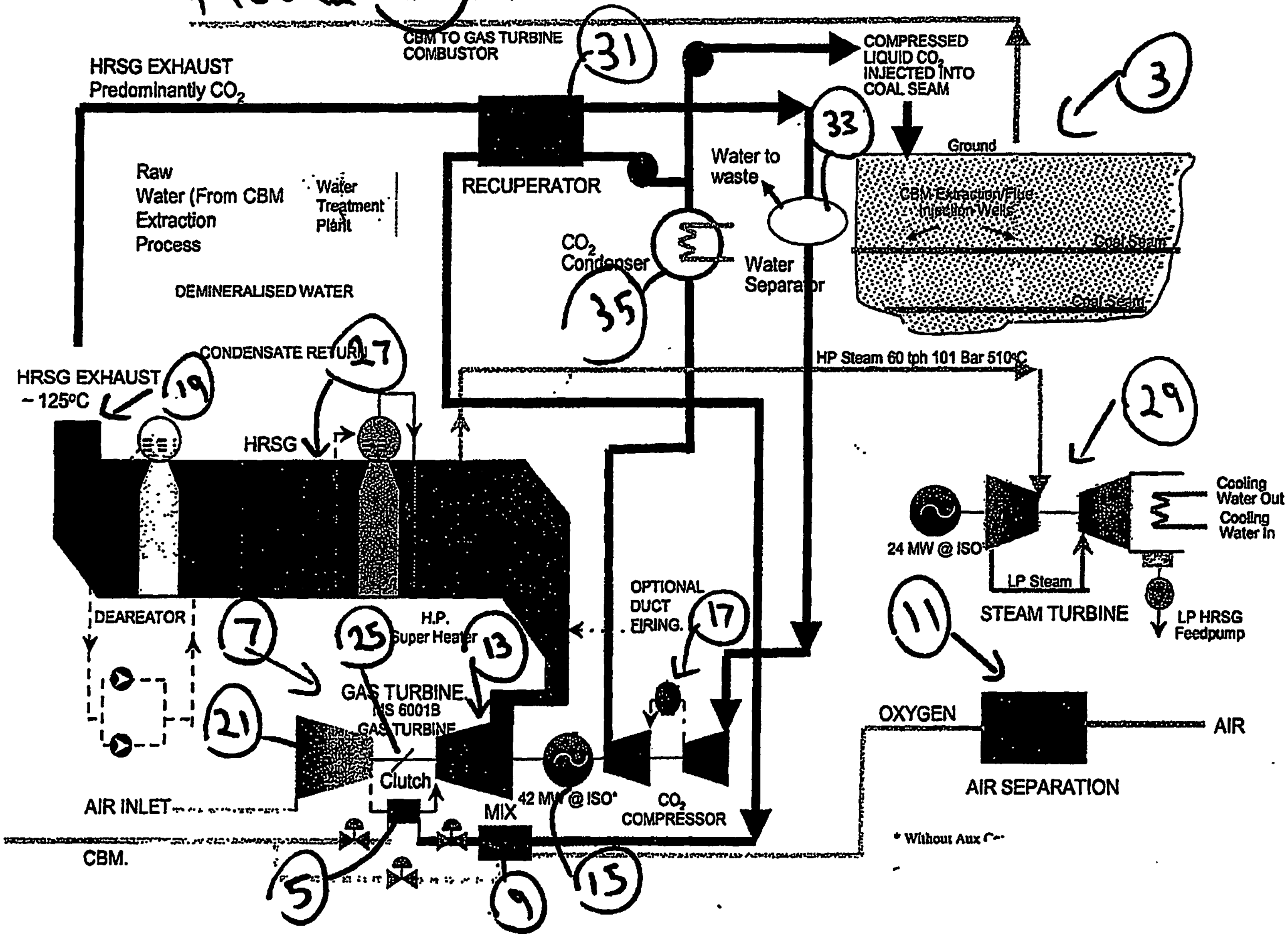
from the spirit and scope of the invention.

FIGURE 1



HRSG EXHAUST
Predominantly CO_2
CBM TO GAS TURBINE COMBUSTOR
COMPRESSED LIQUID CO_2 INJECTED INTO COAL SEAM
Ground
CBM Extraction/Flue Injection Wells
Coal Seam
Coal Seam
3
Raw Water (From CBM Extraction Process
Water Treatment Plant
DEMINERALISED WATER
35
CO_2 Condenser
Water to waste
Water Separator
33
CONDENSATE RETURN
HRSG EXHAUST - 125°C
19
27
HRSG
HP Steam 60 tph 101 Bar 510°C
22 tph 73 Bar
29
Cooling Water Out
Cooling Water In
24 MW @ ISO
LP Steam
STEAM TURBINE
LP HRSG Feedpump
OPTIONAL DUCT FIRING.
17
CO_2 COMPRESSOR
DEAREATOR
H.P Super Heater
7
25
GAS TURBINE.
MS 6001B
GAS TURBINE
21
Clutch
AIR INLET
42 MW @ ISO
MIX
458 tph 22 Bar
CBM.
OXYGEN
AIR
11
AIR SEPARATION
5
9
15

Figure 2



CBM TO GAS TURBINE COMBUSTOR
HRSG EXHAUST Predominantly CO_2
COMPRESSED LIQUID CO_2 INJECTED INTO COAL SEAM
Ground
CBM Extraction/Flue Injection Wells
Coal Seam
Coal Seam
Raw Water (From CBM Extraction Process
Water Treatment Plant
RECUPERATOR
Water to waste
CO_2 Condenser
Water Separator
DEMINERALISED WATER
CONDENSATE RETURN
HP Steam 60 tph 101 Bar 510°C
HRSG EXHAUST ~125°C
HRSG
Cooling Water Out
Cooling Water In
24 MW @ ISO*
LP Steam
STEAM TURBINE
LP HRSG Feedpump
OPTIONAL DUCT FIRING.
DEAREATOR
H.P. Super Heater
GAS TURBINE MS 6001B
GAS TURBINE
Clutch
42 MW @ ISO*
CO_2 COMPRESSOR
OXYGEN
AIR
AIR SEPARATION
AIR INLET
MIX
CBM.
* Without Aux C
3
7
5
9
11
13
15
17
19
21
25
27
29
31
33
35